Dual-Energy Computed Tomography of the Neck

A Pictorial Review of Normal Anatomy, Variants, and Pathologic Entities Using Different Energy Reconstructions and Material Decomposition Maps

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KEYWORDS

• Pictorial review • Dual-energy CT • Head and neck imaging • Virtual monochromatic images • Material decomposition maps • Iodine overlay maps • Virtual unenhanced or noncontrast images • Head and neck cancer

KEY POINTS

- Head and neck anatomy is complex and may be difficult to differentiate from the diverse range of pathologic entities that may be encountered and can make scan interpretation challenging.
- Dual-Energy Computed Tomography (DECT) enables the creation of additional reconstructions not available with conventional single-energy computed tomography that may help diagnostic evaluation in the neck.
- Radiologists using DECT must be familiar with the appearance of normal anatomy and different pathologic entities on specialized DECT reconstructions for optimal use and diagnosis.
- This article provides a practical, pictorial review of the appearance of normal anatomy and diverse pathologic entities of the neck on different DECT reconstructions.

INTRODUCTION

There is increasing use of dual-energy computed tomography (DECT) for the evaluation of head and neck pathologic entities.[1–13] To take full advantage of DECT, radiologists must be familiar with the appearance of normal tissues and pathologic entities on the various reconstructions that can be generated for use in clinical practice. This article provides a practical, pictorial review of the appearance of normal anatomic structures and a broad range of different head and neck pathologic

Disclosures: R. Forghani has acted as a consultant for GE Healthcare and has served as a speaker at lunch and learn sessions titled "Dual-Energy CT Applications in Neuroradiology and Head and Neck Imaging" sponsored by GE Healthcare at the 27th and 28th Annual Meetings of the Eastern Neuroradiological Society in 2015 and 2016 (no personal compensation or travel support for these sessions). A.P. Lara declares no relevant conflict of interest.

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Neuroimag Clin N Am ■ (2017) ■–■

http://dx.doi.org/10.1016/j.nic.2017.04.005

1052-5149/17/

neuroimaging.theclinics.com

entities, both neoplastic and nonneoplastic, on commonly used DECT reconstructions using a fast kilovolt peak switching DECT scanner (GE Healthcare, Waukesha, WI).

OVERVIEW OF DIFFERENT DUAL-ENERGY COMPUTED TOMOGRAPHY RECONSTRUCTIONS

Different DECT approaches and systems, the fundamental principles behind DECT and DECT material characterization, and a detailed review of the evidence behind specific head and neck applications can be found in separate articles in this issue and will not be discussed here. However, the different types of reconstructions commonly generated when using fast kilovolt peak switching DECT systems are briefly reviewed. These include virtual monochromatic images (VMIs) and basis material decomposition maps.

VMIs are images reconstructed at predetermined or prescribed energies that are possible using DECT. Essentially, these are reconstructed based on the data acquired at the 2 different energies and simulate what an image would look like if the scan was acquired with a monoenergetic beam at a given energy. VMIs at 65 or 70 keV are typically considered equivalent to a standard 120 kilovolt peak [kVp] single-energy computed tomography (SECT) acquisition and can be used as a replacement for the latter for routine clinical interpretation when obtaining DECT scans.[6,9] At the authors' institution, where a fast kilovolt peak switching DECT scanner is used, 65 keV VMIs are generated for every neck scan for routine clinical interpretation, based on 2 prior studies evaluating the signal-to-noise ratio and other parameters specifically for neck scans using this type of scanner.[5,7]

In addition to the standard SECT equivalent VMIs, VMIs can be reconstructed at a wide range of energies, between 40 and 140 keV, with this type of scanner. Different energy reconstructions can be used to supplement 65 or 70 keV VMIs for specific clinical applications to improve diagnostic evaluation. For example, VMIs reconstructed at energies lower than 65 or 70 keV can increase iodine attenuation and soft tissue contrast. These have been shown to improve visibility of enhancing structures and lesions, such as head and neck squamous cell carcinoma (HNSCC), although with most DECT systems, this comes at the expense of increased image noise.[5,10,11] At the authors' center, 40 keV VMIs are reconstructed automatically for all neck DECT scans (in addition to the 65 keV VMIs).

VMIs reconstructed at high energies can help with the distinction of nonossified thyroid cartilage (NOTC) from tumor and for reduction of artifact from metallic hardware or dental material.[4,14–20] The tradeoff with increasing VMI energies is a decrease in the attenuation of iodine and, therefore, tissue enhancement, along with decreased soft tissue contrast.

A third type of reconstruction generated with DECT is the basis material decomposition map.[21,22] These maps use differences in the energy-dependent attenuation of materials for identification and classification of their various composite elements based on their relation to the expected energy-dependent characteristics of known materials. In simple terms, these maps can be used to demonstrate the distribution of a material of interest and provide an estimate of its concentration within tissues. They can also be used to remove or subtract a given material from the images. Some common examples of material decomposition maps are iodine (or iodine overlay) maps representing the distribution and estimated content of iodine within different tissues or the virtual unenhanced or noncontrast images that remove iodine from images (eg, for creation of an image set equivalent to a noncontrast acquisition from a single contrast-enhanced study, eliminating the need for a multiphase protocol in some situations).

Although basis material decomposition maps can be very useful for characterization of materials, the radiologist must be aware of their limitations. In contradistinction to well-controlled experimental conditions, materials or fluids in vivo are mixtures and not pure solutions. Material decomposition maps are very useful for distinguishing elements with significant differences in their spectral or energy-dependent attenuation properties. However, the presence of other materials in solution can potentially affect the results, depending on their respective energy-dependent characteristics. Furthermore, the radiologist must keep in mind that material characterization is performed by cross-correlating the attenuation properties to that of known materials and these images should not be interpreted as the physical distribution of a pure solution. As an example, calcified tissues or bones have high signal both on the iodine and water axes of an iodine-water basis decomposition map and, therefore, will retain high signal on an iodine-water map that should not be misinterpreted as high iodine content (eg, high signal of bone on the iodine map in **Fig. 1** and other figures that follow). However, this pitfall can be easily avoided by cross-correlating with the standard 65 keV images. When necessary, additional maps (eg, calcium maps) may be generated for more accurate tissue